SECRET

29 September 1964

MEMORANDUM FOR: Assistant for Plans and Development, NPIC

SUBJECT: Crossed Phase Gratings for the Direct Image Viewer

REFERENCE: Direct Image Viewer, Specification for, [redacted], 25 August 1964

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1. The [redacted] has developed a technique for fabricating phase gratings of extremely high dispersion and good optical quality, at a relatively low cost. A patent search is currently underway by the Agency, prior to filing a patent claim. These are gratings which diffract by operating on the phase of the incident illumination rather than its amplitude, and have a very low absorption coefficient. The process is based on the etching of a photographic emulsion which leaves a greatly enhanced relief image of a crenelate amplitude pattern. It is possible to produce two such gratings on the same surface, oriented at right-angles, so that the resultant diffraction pattern is spread out symmetrically in a plane. The distribution of the energy within this pattern can be controlled through the grating constants and the processing parameters. Given the same emulsion on a stock of plates, the process is highly reproducible and reliable. Current gratings are being produced in a 2-inch square format on 4 x 5 plates. No further advancement in the state-of-technology is required to make these gratings practical in a larger size.

25X1A 2. The Direct Image Viewer requires diffraction gratings for its operation. [redacted] the holder of the prime contract, is currently subcontracting with [redacted] to develop diffraction grating 25X1A replicas for this viewer. The program recently completed Phase I -- a theoretical study of the feasibility of ruling such gratings. The results were promising, but will not meet the specifications cited in the reference. A conference on 24 September 1964 which culminated Phase I efforts divulged that [redacted] has not the slightest hope of meeting the specifications 25X1A (arbitrary though they may be). Deviation from specifications may not be too large, but since making diffraction gratings still remains an art, little can be safely predicted without the confirmation of experiment. Phase II is currently proceeding -- trial rulings with the groove shape dictated by the Phase I results. Details of this are given in the Phase I 25X1A report from [redacted]. If the first trial is successful (and that probability is prohibitively low) and Phase III is entered immediately,

no gratings useful to the viewer can be delivered until at least 1 April 1965, at which time the viewer should already have been built and assembled for approximately 45 days. In the more likely event that additional trials are needed to develop the proper groove-shape (at 2 months per trial), evaluation of the already-assembled viewer will be further delayed -- by as much as nine months.

3. The reference specifies the energy distribution which the gratings must meet, as well as their basic periodicity, and assigns tolerances to those quantities. The specifications are for single gratings -- those with rulings, or lines, running in only one direction. It is the intention of the contractor to use two such gratings, made separately, oriented so that the "lines" of one are at right angles to the "lines" of the other. To ascertain how well the [redacted] phase gratings meet the specifications, the required energy distribution must be re-computed to allow for the two-dimensional pattern. These are listed in the following table, together with a tabulation of data measured from one of the [redacted] experimental crossed phase gratings.

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SPECIFICATION	Single	Crossed	[redacted]
Maximum allowable variation in the ratio of energy in adjacent orders (3.4.3.5)	1.4	1.5	1.44
Maximum allowable drop in intensity from brightest to least bright order in pattern. (3.4.3.5)	2:1	4:1	5:1
Minimum allowable percent of incident energy in the order of least intensity. (3.4.3.6)	3%	0.1%	0.16%
Number of orders required in pattern (minimum).	13	169	169
Period of grating (lines/inch).	702	702/702	796/796

It is easily seen that except for the second and fifth lines, the 25X1A [redacted] experimental gratings meet the specifications. The 5:1 ratio can be dropped to within specification by changing the ratio of line-to-space on the Ronchi ruling used for originating the process. This can easily be accomplished by specifying the appropriate line width on the new 700 lines/inch, 10 x 10 inch Ronchi ruling which must be procured for 25X1A producing the [redacted] gratings. The planeness of the glass which is to be used in the viewer is specified as 0.003 inches/linear inch. The glass figure 25X1A which the [redacted] intends to use in 0.00002 inches/linear inch -- nearly two orders of magnitude better. In summary, the [redacted] Branch can produce the 25X1A required gratings without dependence on a state-of-technology breakthrough, and have in fact been doing just that in a 2-inch square size for nearly two months prior to the writing of this note.

4. The cost of producing the crossed phase gratings depends primarily on the cost of the high-quality Ronchi ruling necessary to the process. This ruling must be of 700 lines/inch ± 5%, with a precisely maintained ratio of line-to-space, and have no significant periodic error in spacing or opacity variation in the lines. It could cost as much as [redacted] and 25X1A 25X1A as little as [redacted] Since the photographic plates are needed in such fine flatness, in a special emulsion, it will be necessary to purchase a minimum order quantity which will be well in excess of the one (1) crossed ruling required. However, these can be used for subsequent gratings, or for other purposes, so that the cost of a single grating is not necessarily 25X1A excessive -- just difficult to amortize to provide a fair evaluation of cost against the [redacted] figures. Accounting for labor without figuring in an overhead rate, the total cost of producing the first ruling could range 25X1A from [redacted] depending on the cost of the Ronchi ruling. However, each subsequent crossed grating reduces this figure proportionately. Actually, the first one could cost the figures cited, while the remainder could cost nothing. The amortization is again difficult, since the total number of gratings to be fabricated is not precisely known.

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5. Comparing the cost figures against [redacted] is difficult. If their 25X1A program is terminated after the first two parts of Phase II (which is the most likely stage), approximately [redacted] will remain unexpended [redacted] 25X1A each, for two remaining trials, [redacted] for Phase III). This would effect 25X1A a savings of from [redacted] Termination of the [redacted] 25X1A 25X1A contract during Phase II, may be premature, and should only be done after a thorough study of the problem. It is not advocated by this Branch at this time. It is properly a decision which should be made by the Development 25X1A Branch. The long-term aspects of the problem must be considered, as well as the working relationship that Branch must maintain with [redacted]

Savings could be increased when future viewers are considered, since their gratings could effectively be produced cost-free. What [redacted] would 25X1A
25X1A charge for such gratings is difficult to predict at this time, but could be in excess of [redacted] each. This may be unfair to [redacted] and such a 25X1A
figure is entirely an unsubstantiated opinion, based on an estimate of what the "traffic might (or might be asked to) bear."

6. In view of the possible savings, in both time and money, and since the original specifications can easily be met, it is suggested that
25X1A the [redacted] Branch be authorized production of crossed phase gratings for use in the Direct Image Viewer. This authorization is requested as soon as possible, since procurement of the necessary Ronchi ruling will be the governing factor in the delivery schedule for the first grating. It will be possible to produce the first grating within one month of receipt of
25X1A the ruling. It is further suggested that immediate consideration be given to the status of the [redacted] program, to determine the advisability and/or necessity for a parallel effort by the [redacted] Branch. Your attention 25X1A
is directed to the contract monitor's report on the Phase I results, indicating the usefulness of carrying out Phase II efforts until at least the second trial ruling.

[redacted] 25X1A

Chief, Exploratory Development Laboratory Branch,
P&DS

Distribution:
Original and 1 - Addressee

MEMORANDUM FOR: Ron w —

Here is a copy of my memo on the shade gratings - for your file. We have been authorized to proceed into production as of 2 October 1964.

Dick 20 Oct 1964
(DATE)

FORM NO. 101 REPLACES FORM 10-101
1 AUG 54 WHICH MAY BE USED. (47)